

ANNUAL PLAN

2016-2017

OF



**CENTRE FOR MATERIALS
FOR ELECTRONICS TECHNOLOGY
(C-MET)**

www.cmet.gov.in

STATUS OF THE PROJECT

Centre for Materials for Electronics Technology (C-MET) has been set up as a Registered Scientific Society in March 1990 under Department of Electronics and Information Technology , DeitY (formerly Department of Electronics) as an unique concept for development of viable technologies in the area of materials mainly for electronics. C-MET is operating with its laboratories located at Pune, Hyderabad and Thrissur. C-MET'S mission is to develop knowledge base in electronics materials and their processing technology for Indian industries and to become a source of critical electronic materials, know-how and technical services for the industry and other sectors of economy.

PROGRESS ACCOMPLISHED DURING 2014-2015

During the year 2014-2015, C-MET has implemented 20 sponsored projects in the following core programs viz.

- Integrated Electronics Packaging
- Nanomaterials, Thickfilms and Nano Composites
- Ultra High Purity Materials and Compound Semiconductors
- Materials for Renewable Energy and Sensors
- E-Waste Management
- NABL accredited RoHS facilities
- Sensors and Actuators
- Aerogel and Graphene for Supercapacitors

During the year, 8 projects were completed and 10 new projects were initiated. The characterization and allied services were extended to outside organization on chargeable basis which generated revenue to the tune of Rs. **301.19** lakhs (from 01.04.2014 to 31.03.2015).

SUMMARY OF UNITWISE TECHNICAL PROGRESS DURING 2014-15

i) Pune Laboratory

The salient features of the progress made during the year 2014-2015 at C-MET, Pune consisting of **Electronics Packaging, Nanomaterials/ Nano composites and Materials for Renewable Energy** are as follows:

Integrated Electronics Packaging

- 1000 Nos of “specific thin film packages” samples were submitted to BARC
- The general purpose in-house, LTCC tapes fabricated at C-MET Thrissur have been tested in the LTCC facility at Pune. Accordingly, the tape composition is being modified
- Screen printable configurable Ag based conductor paste for LTCC has been

developed at CMET Pune. The properties are comparable with the imported paste

- Three different designs of microwave substrates viz Dipole antenna, Filter circuits and monopulse comparator have been fabricated
- Few Numbers of Mark-I samples of magnetic sensor have been fabricated
- A co-deposition bath for electro-deposition of CNT-Lead-free Sn-Ag-Cu film was developed. Characterization of the electrodeposited film confirmed the co-deposition of CNT along with lead-free solder

Nanomaterials, Thickfilms and Nano Composites

- Developed Q semiconductor-glass nano composites at 4Kg scale
- Glasses with quantum dots ranging from 3 to 20 nm synthesized for Magneto-optical measurements
- Optimisation and characterisation of Cu and Fe nanopowders by varying the reactor parameters viz. pressure and power were completed
- To increase the life of graphite crucible and the effect of plasma power on graphite crucible life, copper nanopowders were synthesised at low plasma power (13-16 KW) while keeping reactor pressure constant (14.5 psia)
- Under optimised conditions Copper nanopowders were synthesized at a production rate \sim 250 g/hr with particle size $<$ 100 nm in size
- Thick film conductor paste was formulated using synthesized Cu nanopowders

Materials for Renewable Energy and sensors

- Synthesized ZnIn_2S_4 and CdIn_2S_4 for Hydrogen Sulphide splitting trials in presence of natural sunlight
- Hydrogen evolution via H_2S splitting experiments conducted using glass prepared by melt and quench and sol gel methods
- The Prototype Hybrid Solar Cell using CdS: P3HT with cell efficiency of 0.6 % was developed. The consistent efficiency of the cell is found to be 0.3 %
- Microwave synthesis process for preparation of CdS, CdSe, TiO_2 , ZnO etc completed
- Synthesis of CdS/ ZnO nano composites for visible light active H_2 generation completed
- 1-D CdSe nanorod prepared for HSC
- Developed RuO_2 and $\text{Bi}_2\text{Ru}_2\text{O}_7$ based piezoresistors showed good reproducibility, repeatability with the gauge factor (GF_L and GF_T) respectively in the range of 7-15 and 2-4
- Upscaling of undoped and Cu doped CdS nanostructures to few grams per reaction has been accomplished. Prototype car dimmer has been fabricated at lab scale using photoimageable nanoscale Cu doped CdS photo conductor paste

ii) Hyderabad Laboratory

The salient features of the progress made during the year 2014-2015 at C-MET,

Hyderabad Laboratory consisting of **Ultra Pure & Special Materials (Metals, Alloys and Refractory Materials), Compound Semiconductors, E-waste and RoHS compliance** are as follows:

Ultra High Purity Materials and Compound Semiconductors

- Process & safety documents for hafnium (Hf) sponge have been prepared and submitted to the sponsoring agency, namely VSSC, Thiruvananthapuram
- 99% pure Hf with respect to Zr was prepared by solvent extraction process and nearly 212 Kgs of HfO₂ was prepared
- Briquetting and chlorination processes were completed for 100 Kgs of HfO₂ and 56 kgs of HfCl₄ was successfully prepared
- 30 Kgs of Hf reduced mass was generated by Kroll reduction process
- Finally 18 kgs of Hf Sponge was prepared by Vacuum distillation process (Final Process)
- Two batches of production processes were successfully demonstrated to VSSC-Quality Control (QC) team
- Purified germanium samples have shown around 6N purity excluding gaseous and gas-forming impurities
- Characterization of 6H & 4H SiC single crystals grown at C-MET, Hyderabad was carried out in association with Solid State Physics Laboratory (SSPL), DRDO, New Delhi
- The design of GaN crystal growth system was finalized for fabrication

Materials for Renewable Energy and Sensors

- 6 Kg each of high pure tellurium and cadmium were prepared for conversion into their respective compounds for the fabrication of CdS/CdTe Thin film solar cells
- Viable process methodologies for preparation of CdCl₂ and CdSO₄ were optimized

E-Waste Management

- MoU between C-MET & DeitY, C-MET and KBITS (Government of Karnataka), C-MET & e-Parisara, Bangalore have been signed during September 2014, November 2014 and February 2015, respectively
- E-Waste processing experiments on smelting and electrowinning have been established
- Rs. 14.79 lakhs revenue has been generated through RoHS and non RoHS analytical services to the industry

NABL accredited RoHS facilities

- Technical audit by Bureau of Indian Standards (BIS) under Laboratory Recognition Scheme (LRS) for testing of mercury in Compact Fluorescent Lamps (CFLs), first in the country, have been successfully completed
- An industry meet for the industry awareness of RoHS was organized at New Delhi in association with ELCINA during September 2014

iii) Thrissur Laboratory

The salient features of the progress made during the year 2014-2015 at C-MET, Thrissur Laboratory consisting of **Microwave Dielectrics, Multilayer Ceramics, Sensors & Actuators, Nanomaterials & Thin films and Aerogels** are as follows:

Integrated Electronics Packaging

- Reliability studies performed on indigenously developed microwave substrates by fabricating high power solid state amplifiers and integrating into INDUS-2 particle accelerator at RRCAT, Indore with an output power of 540 W
- 300 Nos of ultra low loss microwave substrates meeting all targeted specifications were delivered to the user agency viz. RRCAT, Indore
- Prepared phase pure microwave ceramic filler materials in the alkaline earth niobate system
- Developed low loss and medium permittivity composite dielectrics for radial power combiners
- Fabricated 25 Nos. of 8"x8" size Cu-cladded microwave substrates having a dielectric constant of 6.15 ± 0.15 and loss tangent of 0.002 @10 GHz
- Band pass filters operating in the frequency range 5.1 to 5.7 GHz have been fabricated and successfully tested
- Synthesized single phase cordierite in 300 g batches using natural minerals as the raw materials

Nanomaterials, Thick-films and Nano Composites

- Established Pilot plant facility for production of Nano-ZnO. As synthesized material was tested, at SUD-CHEMIE India, Cochin, and found to meet all the targeted requirements for desulpharisation applications
- Developed titania nanotube and nanorod on the surface of FTO and Ti metal surface for Dye Sensitized Solar Cell (DSSC)

Sensors & Actuators

- Prepared PVDF thin films having transparency of >92% for acoustic actuators and sensor
- Photomechanical actuators having very high photo actuation were developed using graphene-polymer nanocomposites. A process for the preparation of the photomechanical actuators was developed. An Indian patent was also filed on this
- Graphene - PDMS nano-composite photoactuators developed have photomechanical stress almost double than that of carbon nano tube (CNT) – PDMS nanocomposites
- Demonstrated photomechanical actuation of graphene-polymer nanocomposites
- Fabricated ML stack actuator exhibiting expected properties sent to LEOS, ISRO for evaluation
- Reproducibility of characteristics of PZT rings and PZT Discs for the underwater SONAR transducers applications have been established at system level (at NPOL, Cochin)
- 10 Kgs of piezoceramic composition equivalent to PZT 5J have been prepared as per CEL, Sahibabad specification

Aerogel and Graphene for Supercapacitors

- Fabricated aerocapacitors of capacitance ~25F showed good electrical performances
- Developed graphene supercapacitors having specific capacitance varying from 0.5F to 30F and equivalent series resistance(ESR) up to 0.2 ohms
- Synthesized titania aerogel having surface area in the range of 150-169 m²/g as anode for dye sensitized solar cell

RESEARCH PERFORMANCE INDICATORS during 2014-15

S.No	Activity	Status (2014-15)
1.	Research publications in peer-reviewed journals	72
2.	Conference presentations	96
3.	Invited talks	115
4.	Awards and Honors	12
5.	Patent applications	20
6.	Fellowships/visits (Abroad)	01
7.	International/ National conferences organized	03

LIKELY EXPENDITURE FOR 2015-16

S. No.	Head of Accounts	2015-16	
		Budgetary Estimates (Rs. in lakhs)	Revised Estimates (Rs. in lakhs)
1.	Grant-in-aid (Salaries)	1030	1010
2.	Grant-in-aid (Capital Assets)	785	895
3.	Grant-in-aid (General/Revenue)	395	355
TOTAL	Plan	2210	2260
	Non-plan	100	60
NET BUDGETARY SUPPORT		2310	2320

S. No.	Description	Targets for 2015-16
1.	IR	160
2.	EBR	1700
Total		1860

PROJECTS PLANNED FOR 2016-17

C-MET will continue its program on development of advanced electronic materials and technology through intra-inter laboratory research integration.

Based on their importance and role in the future electronics technology vis-à-vis C-MET's capability to execute them and produce the desired end-results, it is proposed to implement programs viz.

- Integrated Electronics Packaging
- Nanomaterials, Thickfilms and Nano Composites
- Ultra High Purity Materials and Compound Semiconductors
- Materials for Renewable Energy and Sensors
- E-Waste management
- NABL accredited RoHS facilities
- Sensors and Actuators
- Aerogel and Graphene for Supercapacitors

C-MET has prepared plan to execute the projects during 2016-2017 which are given below.

C-MET, PUNE

It is proposed to initiate/continue the development work on:

- LTCC Based Packaging
- HTCC Based Packaging
- WS₂-glass Nano-composite for gamma ray shielding
- Development of Active Materials (Cathode & Anode) for High Energy Density Lithium-ion Cell/Battery with prototype fabrication
- Novel solar light driven bismuth sulphide quantum dot-glass nano-composite photo-catalyst for hydrogen generation
- PdTe Nano-powders for Thermoelectric Applications
- Development of visible light Active Titanium oxynitride and tantalum oxynitride Photo-calysts for H₂O Splitting
- Prototype Development of Fuel Cell using nano functional materials
- Efficient waste water treatment using Novel Catalyst
- Materials for renewable energy and sensors

C-MET, HYDERABAD

It is proposed to initiate/continue the developmental work on:

- Development and Studies on the recovery of cobalt from spent Lithium ion batteries
- Establishment of Silicon Carbide (SiC) Single Crystals Wafer Processing Technology for electronic devices application
- Development of Process technology for the extraction of rare earths oxides (Yttrium, Europium & Terbium) from the spent fluorescent lamps
- Design and fabrication of an indigenous induction zone refiner for germanium purification
- Development of process technology for the preparation of ultra high purity germanium for detector applications
- Production of Hf sponge at 320 kg per annum
- Sustainability and upgradation of Government owned Restriction of Hazardous Substances (RoHS) test laboratory
- Organization of Industry Awareness Programme on RoHS
- Development of process schemes for the recovery of precious metals from waste PCB's
- Fabrication of crystal growth system for preparation of GaN for optoelectronic applications

C-MET, THRISSUR

It is proposed to initiate/continue the developmental work on

- Development & setting-up of pilot plant for production of aerogel supercapacitor for electronic applications
- Development of Powerpacks with aerogel supercapacitors for power electronics.
- Development of titania aerogel based Dye sensitized solar cells and evaluation of its performances
- Development of thermal sensor based monitoring system for the early detection and screening of breast cancer
- Development of NTC thermistor for RADIOSONDE and meteorological balloon application
- Development of graphene based transparent electrodes for thin film acoustic actuators and sensors
- Development of graphene supercapacitors for power electronics
- Synthesis and supply of 50 kg of cristobalite to ISRO
- Development of thin film solar cell with earth-abundant kesterite absorber
- Development of transparent conducting oxide based plasmonic materials and devices
- Evaluation of photosensitive H₂ generation using nano-sized TiO₂ based materials.
- Development of composite laminates for microwave circuit applications
- Development of ULTCC materials for multilayer circuits
- Development of composite insulators and dielectric resonators for dual band combiner filters/dividers

- Development of LTCC material and tape for electronic packaging
- Development of Al internal electrode based μ -LTCC material for electronic packaging
- Magneto-dielectric substrates for miniaturized antenna application
- Development of Nano-dielectrics for enhancement of HV power and submarine cable Insulations
- Development dye/ quantum dot/ perovskite sensitised flexible solar cells
- Development of Planar Wave guides for optical amplification applications

**Budget Estimates, Expenditure for 2014-15 2015-16 &
Revised Estimates for 2015-16 and Budget Estimates for 2016-17**

(Rs. in lakhs)

S. No.	Head of Accounts	2014-2015		2015- 2016		2016- 2017
		Budget Estimates	Actual Expenditure	Budget Estimates (Revised)	Actual Expenditure (From 1.04.2015 to 31.08.2015)	Budget Estimates
1.	Grant-in-aid (Salaries)	930.00	946.43	1030.00	356.81	1140.00
2.	Grant-in-aid (Capital Assets)	730.00	39.08	785.00	28.48	800.00
3.	Grant-in-aid (General/ Revenue)	440.00	561.28	495.00	147.55	540.00
	Total	2100.00	1546.79	2310.00	532.84	2480.00
	Plan	2000.00	1480.50	2210.00	980.85	2380.00
	Non-plan	100.00	60.00	100.00	60.00	100.00
	NET BUDGETARY SUPPORT	2100.00	1540.50	2310.00	1040.85	2480.00

Rs. in lakhs

S. No.	Description	2014-2015		Targets for	
		Target	Actual	2015-2016	2016-2017
1.	IR	140	301.19	160	160.00
2.	EBR	1560	2209.57	1700	1700.00
	Total	1700	2510.76	1860	1860.00